Observed HR diagrams and stellar evolution: the interplay between observational constraints and theory
ASP Conference Series, Vol. ???, 2001
Thibault Lejeune and João Fernandes, eds.

The BaSeL library as a basic tool to provide fundamental stellar parameters of future space missions: COROT and GAIA.

E. Lastennet

Depto. de Astronomia, UFRJ, Rio de Janeiro, Brazil

T. Lejeune

Observatório Astronómico da Universidade de Coimbra, Portugal

F. Cuisinier

Depto. de Astronomia, UFRJ, Rio de Janeiro, Brazil

Abstract. COROT and GAIA are two future major space missions directly connected to most of the stellar astrophysic questions, from stellar physics to evolution of galaxies. We describe a project for the preparation of these two missions by using the possibilities of the *"BaSeL" models*, a library of theoretical stellar energy distributions, to provide automatically the fundamental stellar parameters of the candidate stars. We present the results already obtained for the stars of the COROT main programme.

1. Brief description of the BaSeL models

The Basel Stellar Library (BaSeL) is a library of theoretical spectra corrected to provide synthetic colours consistent with empirical colour-temperature calibrations at all wavelengths from the near-UV to the far-IR (see Cuisinier et al. 1996 for the correction procedure, and Lejeune et al. 1998 and references therein for a complete description). These model spectra cover a large range of fundamental parameters ($2000 \leq T_{\rm eff} \leq 50{,}000$ K, $-5 \leq$ [Fe/H] ≤ 1 and $-1.02 \leq \log g \leq 5.5$) and hence allow to investigate a very large panel of multi-wavelength astrophysical questions.
The BaSeL library spectra have been calibrated directly for standard dwarf and giant sequences at solar abundances and using UBVRIJHKLM broad-band photometry, and are hence expected to provide excellent results in these photometric bands. Since they are based on synthetic spectra, they can in principle be used in many other photometric systems taken either individually or simultaneously, and this is another major advantage of these models. Moreover, their photometric calibrations are regularly updated and extended to an even larger set of parameters (see Lejeune et al. 1998 and references therein). In the two next sections we describe how we intend to apply this library to COROT and GAIA target stars.

2. COROT: major asteroseismology space mission

COROT (**CO**nvection and **ROT**ation) is a space experiment dedicated to ultra high precision, wide field, relative stellar photometry, for very long continuous observing runs on the same field of view. It has two main scientific programs working simultaneously on adjacent regions of the sky: asteroseismology and search for extrasolar planets. To perform an optimal selection among the potential targets it is necessary to know their fundamental parameters. One of the objectives of the preliminary study of target characterization for the central seismology programme of COROT (Lignières et al. 1999) was to choose the appropriate method(s) to determine the basic parameters of the potential targets of this programme (T_{eff}, log g, abundances, vsini, multiplicity). One of these methods is based on the BaSeL library.

Given a set of effective temperature, surface gravity and metallicity (T_{eff}, log g, [Fe/H]), the BaSeL models provide various colours that can be directly compared with stellar populations. The inverse method (Lastennet et al. 1999) is as well very useful to derive the atmospheric parameters from the observed colours: Lastennet et al. (1999) applied this method to a sample with photometry in the Strömgren system, and obtained very good results from the BaSeL models, in agreement with accurate HIPPARCOS data.

The capability of the BaSeL models to derive simultaneously or individually the (T_{eff}, log g, [Fe/H]) parameters for the main programme stars of the COROT mission has already been shown in Lastennet et al. (2001). For illustration purpose, we show some of the final results we obtain in Figure 1. We propose to develop in the near future an automatic tool based on the method of Lastennet et al. (1999) to complete the facilities of the new "BaSeL interactive server", the web version of the BaSeL models hosted by the Coimbra Observatory since the end of 2000 (`http://www.astro.mat.uc.pt/BaSeL/`, see also Lejeune & Schaerer, 2001 for details). This method would be applied to the $\sim$ 1000 remaining potential targets of the COROT exploratory programme.

3. GAIA: ESA Cornerstone space mission

The GAIA mission, an ESA (European Space Agency) cornerstone mission, has been designed to solve many of the most difficult and deeply fundamental challenges in modern astronomy: to determine the composition, formation and evolution of our Galaxy. GAIA will provide unprecedented positional and radial velocity measurements with the accuracies required to produce a stereoscopic and kinematic census of about one billion stars in our Galaxy (this amounts to about 1 % of the Galactic stellar population) and throughout the Local Group. Combined with astrophysical information for each star, provided by on-board multi-colour photometry, these data will have the precision necessary to quantify the early formation, and subsequent dynamical, chemical and star formation evolution of the Milky Way Galaxy. Additional scientific products include detection of new binary systems, brown dwarves, extragalactic objects (more than 1 million galaxies, 5.10^6 quasars, 10^5 supernovae etc...), with crucial implications for stellar and galactic physic, galactic structure, distance scales in the Local Group, etc...

The core science case for GAIA requires measurement of luminosity, T_{eff}, mass, age, and composition for the stellar populations in our own Galaxy and in its nearest galaxy neighbours. These quantities can be derived from the spectral energy distribution of the stars, through multi-band photometry.
Nonetheless, while many photometric systems already exist (e.g. Johnson-Cousins, Geneva, Strömgren, RGU, Washington, etc...) none satisfy all the GAIA requirements. The GAIA photometric system must be able to classify stars across the entire Hertzsprung-Russell diagram, as well as to identify peculiar objects. It must be able, for example, to determine temperatures and reddening for OBAFG stars (needed as tracers of Galactic spiral arms and as reddening probes), temperatures and abundances for late-type giants and dwarfs, abundance of Fe and α-elements, etc.... Thus it is necessary to observe a large spectral domain, extending from the UV to the far-infrared.
Provided that the new pass-bands of the GAIA space mission (e.g. the 4 broad bands and 11 intermediate bands covering the spectral range 280 to 920 nm, see Cayrel et al. 1999 and `http://wwwhip.obspm.fr/gaia/photometrie.html`) are implemented in the BaSeL models, the new tool described in the previous section will provide automatically (T_{eff}, log g, [Fe/H]) estimates for the stars observed by GAIA.

4. Concluding remarks

COROT and GAIA are two next generation space missions which should provide essential results for stellar evolution theory. Here we present a proposition to develop for these two missions an automatical method, already used with success for COROT potential targets (Lastennet et al. 2001), for a systematic determination of fundamental parameters from BaSeL synthetic multi-photometry. This new tool should be publicly available on the following web site `http://www.astro.mat.uc.pt/BaSeL/` by the end of 2001.

Acknowledgments. EL acknowledges support from CNPq and FAPERJ.

References

Cayrel R., Castelli F., van't Veer C., 1999, Grasse (France), Atelier GAIA, Eds. M. Froeschlé & F. Mignard

Cuisinier F., Lejeune Th., Buser R., 1996, IAU Symp. 171, R. Bender and R.L. Davies (eds), p.355

Lastennet E., Lejeune Th., Westera P., Buser R. 1999, A&A, 341, 857

Lastennet E., Lignières F., Buser R., Lejeune Th., Lüftinger Th., Cuisinier, F., van't Veer-Menneret C., 2001 A&A, 365, 535

Lejeune Th., Cuisinier F., Buser R. 1998, A&AS, 130, 65

Lejeune Th., Schaerer D., 2001, A&A, 366, 538

Lignières F., Catala C., Katz D., Lastennet E., Lüftinger Th., van 't Veer-Menneret C., 1999, Joint European and National Astronomical Meeting (JENAM 99), "Fundamental parameters of COROT potential targets."

Marsakov V.A., Shevelev Y.G., 1995, Bull. Inform. CDS 47,13

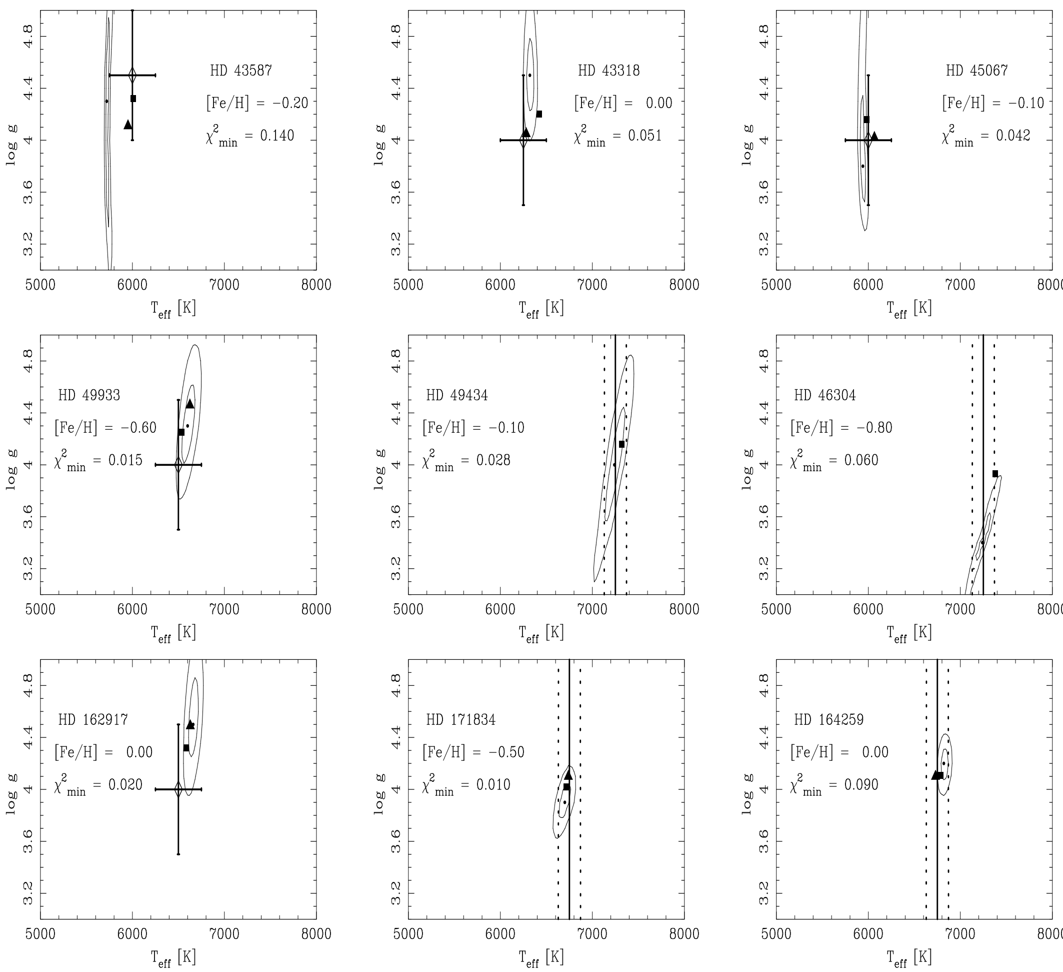

Figure 1. Results in the ($T_{\rm eff}$, log g) diagram for 9 potential targets of the COROT central seismology programme. For each star, the 1- and 2-σ contours are displayed in a [Fe/H] = constant plane, corresponding to the best simultaneous ($T_{\rm eff}$, [Fe/H], log g) solutions derived from the BaSeL models in order to fit simultaneously the observed photometric values (B−V), (U−B) and (b−y). An estimation of the quality of the best fit (χ^2-value) is also quoted in each panel. The results projected in the $T_{\rm eff}$-log g planes from the spectroscopic analysis (*diamond with error bars*, or *solid plus two dotted lines*) as well as from the "Templogg" programme (*square*), and Marsakov & Shevelev (1995) (*triangle*) are also shown for comparison.